Technology News

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Updated Analysis of Longwall Pillar Stability (ALPS) Computer Program Incorporates New Coal Mine Roof Rating (CMRR)

Objective

To develop a comprehensive, practical method for designing longwall gate entries that considers coal pillar size, mine roof quality, and artificial support in an easy-to-use computer program.

Background

Longwall mines now account for more than 40% of U.S. underground coal production, an increase from less than 5% 20 years ago. Improved longwall performance requires stable gate entries that provide safe access to the longwall face. Several years ago, the U.S. Bureau of Mines (USBM) developed the Analysis of Longwall Pillar Stability (ALPS) computer program to help size chain pillars to better protect the gate entries. ALPS built upon the experience at many mines, which found that poor tailgate conditions often improved significantly when pillar sizes were increased. In much of the U.S. coal industry, ALPS has become the standard technique for analyzing longwall pillar design problems.

However, coal pillar design is not the only factor that impacts longwall gate entry performance. For example, a mine with strong roof rock will have better conditions (all other things being equal) than one with a weak roof. The entry width and the amount of artificial support can also be important. The need was evident for a gate entry design method that extends ALPS to account for all of these factors.

Approach

USBM researchers conducted studies at 44 longwall mines representing all of the major U.S. coalfields (figure 1). At each mine, underground observations of site geology, entry conditions, and artificial support were recorded. Discussions with mine personnel provided information on past experience with different gate entry designs used at each mine. Ultimately, 69 U.S. longwall case histories were identified, and the performance of each was characterized as either *satisfactory*, *unsatisfactory*, or *borderline*.

Each case was also described by several design variables. For example, the ALPS stability factor (SF) was used to define coal pillar design. Other rating scales were developed for primary support, secondary support, and entry width. One of the keys to the success of the research was the ability to define roof geology using the USBM's newly developed Coal Mine Roof Rating (CMRR). The CMRR replaces traditional geologic descriptions with a roof competence rating scale of 0 to 100. It weighs the importance of rock strength, bedding plane resistance, fracture spacing, and other factors in determining the overall rating. The CMRR is uniquely advantageous in that it applies to all U.S. coalfields, so that mine roofs can be compared even when their geologies are quite different. Gathering the information needed to compute the CMRR requires only simple field tests and observations.

Statistical analyses of the entire longwall case history database indicated that when the CMRR and ALPS are combined, the performance of a longwall gate entry system can be accurately predicted. Only three cases in the database, or 6%, were misclassified or fell outside a narrow borderline region (figure 2).

Based on these results, a simple equation was developed to guide the design of longwall pillars and gate entries:

$$\text{ALPS } SF_R = 1.76 - 0.014 \text{ CMRR},$$

where ALPS SF_R = ALPS SF suggested for design.

The analyses also confirmed that primary support and gate entry width are essential elements in successful gate entry design. Satisfactory designs in mines with *weak* roof (i.e., CMRR < 45) utilized entries no wider than 5.2 m (17 ft), whereas those with *strong* roof employed entries 5.8 to 6.1 m (19 to 20 ft) wide. The relative importance of the floor and secondary support could not be determined from the data.

Results

The gate entry design methodology that resulted from the study is expected to significantly aid longwall mine planners. It is the first design methodology to focus on the tailgate entry itself rather than only the chain pillars. More importantly, it is based on the scientific interpretation of the ground control experience examined at more than one-half of all U.S. longwall mines. The method thus makes the wealth of U.S. longwall experience available in a practical form.

ALPS version 4.0, an update of the ALPS computer program, has been prepared to aid mine planners. It is written in the C programming language and is an executable file that runs directly from DOS on any PC. The program is menu-driven and is extremely user-friendly and accessible by those with little or no computer background. An on-line help file is also included.

ALPS version 4.0 contains the same formulas for calculating the ALPS SF as earlier versions. As before, it may be used to analyze longwall coal pillar designs employing any number of entries or combination of pillar widths. The method does not apply to pure yield pillar designs, however, such as those used on some western U.S. longwalls.

A new feature of ALPS version 4.0 is the CMRR. After selecting this menu item, users may input the CMRR for their application, and the program will return the suggested ALPS SF for that mine roof. Alternatively, if the CMRR is not known, the user may browse an on-line library of nearly 100 roof descriptions and CMRR values. The library is sorted by State and coal seam, and includes all major U.S. coalfields. The library can also help users verify their own CMRR estimates against observations already made.

For More Information

Single copies of the ALPS version 4.0 computer program may be obtained by sending a blank, formatted diskette to Christopher Mark, U.S. Bureau of Mines, Pittsburgh Research Center, Cochrans Mill Rd., P.O. Box 18070, Pittsburgh, PA 15236-0070.

Additional information on different aspects of gate entry design is contained in the publication "New Technology for Longwall Ground Control. Proceedings: U.S. Bureau of Mines Technology Transfer Seminar" compiled by Christopher Mark, Robert J. Tuchman, Richard C. Repsher, and Catherine L. Simon (1994). This softcover, 145-page proceedings volume may be ordered from: GPO Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954. GPO stock number: 024-004-02299-0. Price: $10.00 (international customers please add 25%). Phone: (202) 783-3238; fax: (202) 512-2250.

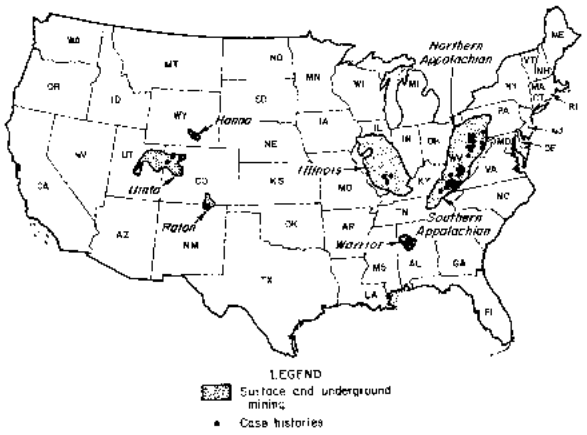

Figure 1.—Location of geotechnical surveys of U.S. longwall mines conducted by USBM ground control researchers.

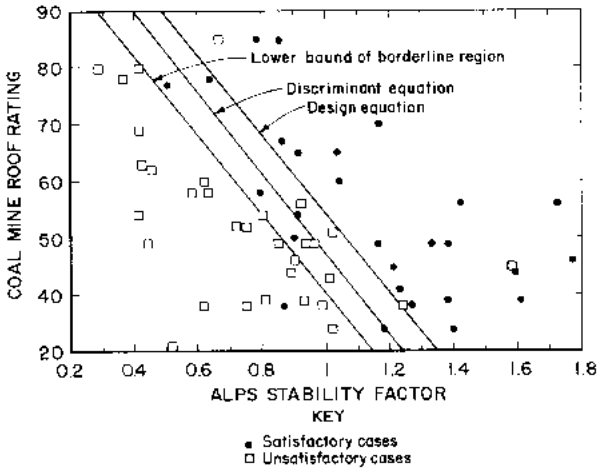

Figure 2.—Design equation determined from U.S. longwall case history database.